DEPARTMENT OF NATIONAL DEFENCE

CANADA

OPERATIONAL RESEARCH DIVISION

DIRECTORATE OF OPERATIONAL RESEARCH (MARITIME, LAND, AIR)

DOR(MLA) RESEARCH NOTE RN 2003/02

DETERMINING CF-18 FLEET SIZE AND AIR FORCE CRITICAL MASS USING ASTRA

By

JAY ADAMSSON

APRIL 2003

OTTAWA, CANADA

National Defence / Défense nationale

106-03083/

OPERATIONAL RESEARCH DIVISION

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JAY ADAMSSON

Recommended by: DAVE MASON
DASOR

Approved by: J. EVANS
DOR (MLA)

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OTTAWA, ONTARIO APRIL 2003

ABSTRACT

This research note considers two questions that were directed towards DASOR. The first concerns proposed changes to the operations of the CF-18 fleet. The second concerned the critical mass of four fleets, defined as the fleet size below which a substantive contribution is no longer possible. These questions were analyzed using the Air Force Structure Analysis (ASTRA) tool.

RÉSUMÉ

Cette note considère deux questions qui ont eté posées à la DROFA. La premiére concerne des changements qui sont proposés aux operations de la flotte des CF-18. La deuxième concerne la masse critıcale de quatre flottes, définie par la grandeur minimale où la flotte peut faire une contribution substantive. Ces questions ont eté analysée avec le modèle Air Force Structure Analysis (ASTRA).

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LIST OF ABBREVIATIONS

ADCTS	Advanced Distributed Combat Training System
AETE	Aerospace Engineering and Test Establishment
AIMP	Aurora Incremental Modernization Program
ASA	Air Sovereignty Alert
ASTRA	Air Force Structure Analysis
BFO	Basic Flying Operations
BFPC	Basic Fighter Pilot Course
CAS	Chief Air Staff
CC	Capability Component
CR	Combat Ready
CS	Combat Support
D Air SP	Director Air Strategic Planning
DAR	Director Aerospace Requirements
DASOR	Director Air Staff Operational Research
JTF2	Joint Task Force 2
MH	Maritime Helicopter
MP & EU	Maritime Proving and Evaluation Unit
MPSET	Maritime Patrol Standardization and Evaluation Team
NORAD	North American Aerospace Defence
OT&E	Operational Test and Evaluation
OTU	Operational Training Unit
PG	Planning Guidance
SAR	Search and Rescue
SNFL	Standing Naval Fleet Atlantic
T&E	Testing and Evaluation
TFS	Tactical Fighter Squadron
YFR	Yearly Flying Requirements

DETERMINING CF-18 FLEET SIZE AND AIR FORCE CRITICAL MASS USING ASTRA

1 – Introduction

1. The Air Force Structure Analysis (ASTRA) tool [1] has been developed to link the military strategic requirements of the air force to pilot, aircraft, and YFR requirements. This tool, first used during the Air Force Structure Exercise (FSX) in 2000, has since become an integral component in force structure studies within the air force. Since the FSX, ASTRA has undergone further evolution, which will be documented in a forthcoming project report. It is also anticipated that ASTRA will be relied upon heavily in major upcoming air force studies, as well as for the anticipated Defence Review.

2. This report outlines the results of two analyses that were conducted using ASTRA. The first request originated from Director Aerospace Requirements (DAR), and involved the air staff response to the document generated at 1 CAD entitled "Canada's CF18 Fighter Force – The Way Ahead" [2]. This document presented a number of recommendations concerning the size and management of the CF18 fleet in the short and medium term future. At the request of DAR, DASOR was asked to provide input on both the analysis and recommendations contained in this document. The analysis and conclusions were summarized in a briefing note [3].

3. The second request came from Director Air Strategic Planning (D Air SP). In anticipation of further requests to either justify or reduce the level of activity within the core fleets of the air force, DASOR was asked to quantify the critical mass of each of these fleets. Critical mass is defined at the level below which the fleet can no longer provide an operationally significant contribution. The results of this analysis were documented in [4].

4. This research note will present the results of the two studies outlined above. In addition, further analysis into these two problems will be described. These two problems, although independently asked and analysed, are presented together herein for two reasons. First, by themselves, each problem would make for a very short report, thus they were combined into a more significant document. Secondly, the same methodology was used for both studies, and hence presenting them together provides a valuable overview of the operation and capability of ASTRA. However, since the two studies are independent, it also follows that the results are independent. When reading the observations at the end of each chapter, it should be remembered that very different assumptions were used to obtain each result.

2 – ASTRA

5. It is often difficult to make the link between strategic requirements of the Canadian Forces and the resources required to meet those commitments. The Government of Canada provides strategic guidance and direction for national defence through the Defence White Paper, last issued in 1994. In the case of the Air Force, these expectations are interpreted in the CAS Planning Guidance [5] as a set of strategic commitments, given by fleet. The ASTRA program is used to compute fleet size requirements given a set of strategic commitments. The strategic commitments available for analysis in ASTRA include those outlined in [5] and also include additional variations to allow "what-if" scenarios. A full description of ASTRA can be found in [1], and also in a forthcoming report. This section will provide a brief overview.

6. The main input to ASTRA is a set of strategic commitments. The output from ASTRA is a detailed number of aircraft, pilots, and yearly flying requirement (YFR) for each fleet required to meet those commitments.

7. In ASTRA, once a set of strategic commitments is selected, the number of aircraft and pilots required to meet that commitment are determined. This calculation considers the size of the commitment, simultaneous taskings, and rotation requirements for sustained deployments. This gives a minimum force employment requirement. However, there are a number of other factors that must be considered after this to determine an overall force structure requirement. The strength of ASTRA lays in its computation of these other demands.

8. In determining force structure, both force employment and force generation have to be considered. In other words, now that we know the size of the force needed to meet the commitments, how much more is required to make sure the force employment requirement is met?

9. In general, the pilots required for force employment are distributed among the current squadrons for each fleet. By using the yearly flying requirement (YFR) per pilot, and adding in extra flying hours for additional taskings, the YFR for each squadron can be determined.

10. The number of aircraft required in each squadron is now the maximum of the aircraft required to fly the calculated YFR, or the aircraft required to meet the specified commitments. Additional aircraft requirements due to maintenance and serviceability are explicitly considered in this calculation in two manners. First, the hours each aircraft can fly are limited by serviceability rates. Secondly, additional aircraft are added to the total to compensate for aircraft not in service due to long term maintenance. This completes the determination of the fleet structure for each squadron.

11. In addition, resources are required for training new pilots. Each fleet has an operational training unit (OTU) that is charged with the training of new pilots to ensure the squadrons have the requisite number of pilots. The number of trainees required is calculated based on attrition and posting rates from the squadrons. This result then drives the number of instructors required at the OTU. Finally, the aircraft and YFR requirement at the OTU is calculated.

3 – Air Force Requirements

12. In order to fully appreciate force structure, the commitments that drive a force structure must first be understood. Based upon the general guidance provided by the government, each year the Chief of the Air Staff (CAS) produces a planning guidance [5] listing the commitments that the air force makes to the government. These are presented below for the four fleets that are analysed in this report.

Capability	Readiness	Sustainability	Deployability	Commitment
8 X Aircraft	H Classified	Indefinite	Canada	National/NORAD
6 X Aircraft	H Classified	Indefinite	Can/US	NORAD
12 X Aircraft	H Classified	180/60 Days Combat Ops	NATO	RRF(A)
12 X Aircraft	H 21 Days	Indefinite (OOTW) 180/60 Days Combat Ops	Worldwide	Vanguard
12 X Aircraft	N 90 Days	180/60 Days Combat Ops	Worldwide	MCF
Balance of Fleet	R 180 Days	N/A	Nil	

Table 1: CF188 Hornet Fleet Commitments

Capability	Readiness	Sustainability	Deployability	Commitment
2 X Aircraft (1 per coast)	H 8 Hours	Indefinite	Canada	CMS
24/7 Operations (Both coasts)	H As Req'd	24/7 for 14 Days	Canada	CMS
2 X Aircraft	H 21 Days	Indefinite	Worldwide	Vanguard
4 X Aircraft	N 90 Days	180/60 Days Combat Ops	Worldwide	MCF
3 X Aircraft	H Classified	180/60 Days Combat Ops	NATO AOR	NATO
3 X Aircraft	N Classified	180/60 Days Combat Ops	NATO AOR	NATO
Balance of Fleet	R 180 Days	N/A	Nil	

Table 2: CP 140 Aurora Fleet Commitments

Capability	Readiness	Sustainability	Deployability	Commitment
1 X HELAIRDET	H As Req'd	Indefinite	NATO AOR	SNFL
2 X HELAIRDET (1 per coast)	H 20 Days	Indefinite	As Req'd by CMS	CMS
4 X HELAIRDET (first TG)	H 90 Days	180/60 Days Combat Ops	As Req'd by CMS	CMS
2 X HELAIRDET (Second TG)	N 180 Days	180/60 Days Combat Ops	As Req'd by CMS	CMS
Balance of Fleet	R 180 Days	N/A	Nil	

Table 3: CH 124 Sea King Fleet Commitments

Capability	Readiness	Sustainability	Deployability	Commitment
3 X Aircraft	H Classified	Indefinite	Canada	Ops
4 X Aircraft (1 per LFA)	H 8 Hours	Indefinite	Canada	CLS
3 X Aircraft	H 30 Mins	Indefinite	Canada	Local SAR Stdby
8 X Aircraft	H 21 Days	Indefinite / Low Threat	Worldwide	Op FORTUNE
8 X Aircraft	H 30 Days	180 Days / Low Threat	Worldwide	UNSAS / SHIRBRIG
24 X Aircraft	N 90 Days	180/60 Days Combat Ops	Worldwide	CLS Op SABRE
Balance of Fleet	R 180 Days	N/A	Nil	

Table 4: CH 146 Griffon Fleet Commitments

13. For the purposes of this study, the capability and sustainability columns in each table are used to define requirements (for further information and explanation of the other entries in these tables, please consult [5]). The number of aircraft and the length of deployment are the two key inputs into determining the overall requirements.

14. These tasks represent the current commitments of the air force to the Government of Canada. However, one of the strengths of ASTRA is that it permits the examination of scenarios in which these commitments are changed. Thus, the impact on force structure of either an augmentation or a diminution of the commitments of the air force can be examined.

15. In section 4 of this report, the impact of reducing the CF-18 Vanguard (as shown in the fourth row of Table 1) from 12 to 6 aircraft is considered. For section 5 of this report, those commitments that are considered absolutely essential for the fleet are considered as a minimum level of commitment, and all others are eliminated.

16. While there are other inputs into ASTRA that can be altered (including training requirements, which are also considered in section 4), the commitments, either taken from the CAS Planning Guidance and reproduced in Tables 1 through 4, or a variation thereof, are the fundamental base for ASTRA calculations.

4 – "CF18 Fighter Force – The Way Ahead" Analysis

17. In July 2002, a briefing note was produced at 1 Canadian Air Division (1CAD) entitled "Canada's CF-18 Fighter Force – The Way Ahead" [2]. The aim of this paper was given as:

> *"...to provide an initial analysis of the viability of current plans for the evolution of Canada's CF-18 fighter force and to make appropriate recommendations for further staffing."*

18. The responsibility for force structure within the air force lies with National Defence Headquarters (NDHQ). The day-to-day management responsibility lies with 1CAD, which is the operational headquarters of the Canadian air force. However, since 1CAD concentrates on running the fleets daily, they have a better perspective of the direct implications of force structure on operational aspects. The communication of problems that arise as a result of force structure must be communicated from 1CAD to NDHQ, along with suggestions on how to improve the situation. It is then the role of NDHQ to assess these suggestions in light of other fleets and other pressures on the air force.

19. Among the suggestions proposed to NDHQ in [2], there are two that were immediate candidates for analysis using ASTRA. The aim of this section is to analyse the feasibility of both of these suggestions.

20. The first suggestion is that the CF-18 Vanguard commitment be immediately restricted to six aircraft. Currently, as shown above in Table 1, the air force is committed to a deployment of 12 aircraft as a Vanguard or Rapid Reaction Force deployment [5]. A reduction of this number to 6 aircraft would reduce the potential strain on the air force in the event of such a deployment.

21. The second recommendation is that the yearly flying rate (YFR) be increased to 210 hours per tactical fighter squadron (TFS) pilot, for a fleet YFR of 20,000 hours. This increase would have the dual impact of increasing squadron experience levels as well as promoting pilot retention. Currently, the YFR is 180 hours per pilot, and 17,800 hours for the fleet. There have been initial estimates within the air staff that this can be reduced to 150 hours per pilot and 16,000 hours for the fleet with the introduction of the Advanced Distributed Combat Training System (ADCTS) [2], the initial operating capability of which is scheduled for no later than end 2004.

22. Although given as two recommendations in the original paper, the interrelationships between these two areas mean that they cannot be looked at individually, but only as part of the overall system. Both the level of commitment and the YFR per pilot are inputs to ASTRA. The resulting output reveals the required level

of resources to meet the demands. By comparing the actual level with the computed requirements, the feasibility of the proposal can be assessed.

23. The basic assumptions for the CF-18 fleet that were used for this analysis are:

- NORAD Air Sovereignty Alert (ASA)[1] has a continuing requirement of eight aircraft, with four additional aircraft as spares for a total of twelve aircraft ;
- NORAD 3322 capability of six aircraft will be maintained at all times;
- Each TFS is limited to 17 pilots. If the requirement is above this level, additional pilots are denoted as "designated" and are allocated a YFR of 60 hours. In practice, these pilots are identified from non-squadron positions and will be called upon if required;
- Basic Fighter Pilot Course (BFPC) requires 92 hours per student;
- Readiness flying and training at home bases for remaining pilots will continue unabated during any deployment;
- Aircraft have a morning serviceability of 50%, and after each flight 40% of those that flew are rendered unserviceable for the remainder of the day; and
- Non-deployed, fully serviceable aircraft will fly an average of 2.5 flights per day and 1.1 hours per flight over 210 days per year.

24. Starting with a level of commitment, ASTRA can provide the required resource level to meet that commitment. Four levels of commitment were considered. These can be thought of as the Vanguard/MCF options and rapid reaction force commitments:

- A commitment of 24 aircraft for a short-term, unsustained deployment. This is an enhanced commitment above that called for in the CAS Planning Guidance [5];
- A commitment of 12 aircraft for a long-term, sustained deployment. This is in accordance with [5];
- A commitment of 12 aircraft for a short-term, unsustained deployment. This is in accordance with [5]; and
- A commitment of 6 aircraft for a long-term, sustained deployment. This is a reduction of the commitment in [5], but follows the recommendation in [2].

Scenario 1 – 210 Hours per Year

25. Setting the YFR per pilot to 210 hours, as recommended in [2], the results are shown in Table 5. These results demonstrate that the CAS Planning Guidance [5] commitment of deploying 12 aircraft on a sustained deployment requires more resources than are currently available. While the current squadron strength is at 68 pilots (17 pilots

[1] NORAD Air Sovereignty Alert (ASA) is the deployment of up to 12 aircraft within Canada. NORAD 3322 is an Operational Plan for the deployment of up to 6 aircraft within Canada or the US. These two plans can be activated simultaneously, and, even when not activated, require the indefinite maintenance of sufficient aircraft and pilots at high readiness.

in each of four squadrons) and the YFR is within a few hours of the current fleet limit, the number of aircraft required is larger than the current fleet size.

	24 Unsustained	12 Sustained	12 Unsustained	6 Sustained
Pilots	77 CR pilots 23 Instructors 16 BFPC Students	64 CR pilots 22 Instructors 15 BFPC Students	53 CR pilots 21 Instructors 12 BFPC Students	51 CR pilots 21 Instructors 12 BFPC Students
Aircraft	15 per TFS 18 OTU 4 AETE 6 Second Line 88 Total	14 per TFS 16 OTU 4 AETE 6 Second Line 82 Total	12-13 per TFS 15 OTU 4 AETE 5 Second Line 73 Total	11-12 per TFS 14 OTU 4 AETE 5 Second Line 70 Total
YFR	3570 per TFS 4164 OTU 1120 Other 19564 Total	3360 per TFS 3813 OTU 580 Other 17833 Total	2730 – 2940 per TFS 3404 OTU 580 Other 15114 Total	2520-2730 per TFS 3322 OTU 580 Other 17833 Total

Table 5: Fleet Requirements at 210 Hours per Pilot per Year

26. At 210 hours per pilot per year, there are sufficient aircraft in the post-modernized fleet[2] to deploy 12 aircraft on an unsustained deployment, or 6 aircraft on a sustained deployment. However, during the modernization, the number of aircraft will be temporarily reduced to 69. This is below the fleet sizes required for even the smaller deployments. The conclusion is that, during the modernization period, at 210 hours per pilot per year, the air force will be unable to carry out any deployments without compromising either NORAD or training requirements.

Scenario 2 – 180 Hours per Year

27. Table 6 continues the analysis at the current 180 hours per year per pilot. The fleet size of 80 aircraft and a fleet YFR limit of 17,800 hours do not restrict any of the commitments. However, currently there are only 64 combat-ready pilots at the TFSs. An increase in these pilots would put the commitment of 24 unsustained aircraft within reach. The number of pilots is not a limitation on any of the other deployments.

[2] The CF-18 fleet is currently undergoing a modernization that will reduce the fleet size by as much as 19 aircraft. The program will be completed by 2011, when the fleet will return to 80 aircraft.

	24 Unsustained	12 Sustained	12 Unsustained	6 Sustained
Pilots	77 CR pilots 23 Instructors 16 BFPC Students	64 CR pilots 22 Instructors 15 BFPC Students	53 CR pilots 21 Instructors 12 BFPC Students	51 CR pilots 21 Instructors 12 BFPC Students
Aircraft	13 per TFS 18 OTU 4 AETE 6 Second Line 80 Total	12 per TFS 16 OTU 4 AETE 5 Second Line 73 Total	10-11 per TFS 15 OTU 4 AETE 4 Second Line 64 Total	9-10 per TFS 14 OTU 4 AETE 4 Second Line 61 Total
YFR	3060 per TFS 4164 OTU 1120 Other 17524 Total	2880 per TFS 3813 OTU 580 Other 15913 Total	2340 - 2520 per TFS 3404 OTU 580 Other 13524 Total	2160-2340 per TFS 3322 OTU 580 Other 13092 Total

Table 6: Fleet Requirements at 180 Hours per Pilot per Year

28. During the modernization, if the fleet size is reduced to 69 aircraft, the commitment of 12 sustained aircraft for deployment is in jeopardy. There is a shortfall of 4 aircraft, or one per squadron. If the fleet is reduced to 69 aircraft, the problem lies not in having aircraft and pilots for deployment, but in having sufficient numbers of aircraft for training. Calculations from ASTRA show that each squadron would have to have 13 aircraft. The reduction of the fleet to 69 aircraft would reduce this to 12 aircraft. The loss of one aircraft would make it difficult for all the pilots in the squadron to meet their readiness requirements. Further investigation would have to be carried out to determine if these requirements can be met with the reduced number of aircraft.

Scenario 3 – 150 Hours per Pilot

29. The final scenario investigated a reduction in flying hours to 150 hours per person. These results are shown in Table 7. Assuming that this reduction will also imply a fleet-wide YFR restriction at 16,000 hours, all of the commitments fall within the YFR and aircraft resource limits, although deploying 24 aircraft would require more pilots than are currently at the squadrons.

	24 Unsustained	12 Sustained	12 Unsustained	6 Sustained
Pilots	77 CR pilots 23 Instructors 16 BFPC Students	64 CR pilots 22 Instructors 15 BFPC Students	53 CR pilots 21 Instructors 12 BFPC Students	51 CR pilots 21 Instructors 12 BFPC Students
Aircraft	11 per TFS 18 OTU 4 AETE 5 Second Line 71 Total	10 per TFS 16 OTU 4 AETE 5 Second Line 67 Total	9 per TFS 15 OTU 4 AETE 4 Second Line 59 Total	8-9 per TFS 14 OTU 4 AETE 4 Second Line 57 Total
YFR	2550 per TFS 4164 OTU 1120 Other 15484 Total	2400 per TFS 3813 OTU 580 Other 13993 Total	1950 – 2100 per TFS 3404 OTU 580 Other 11934 Total	1800-1950 per TFS 3322 OTU 580 Other 11562 Total

Table 7: Fleet Requirements at 150 Hours per Pilot per Year

30. The expanded commitment of 24 aircraft in a single-rotation deployment would require more pilots than are currently present, but the other requirements can be met. During the modernization, there may be a shortage of aircraft, but only by two aircraft. Any of the other commitments are achievable, even during the modernization period.

31. Although ASTRA demonstrates that at 150 hours per year per pilot, a reduced YFR will suffice to continue a commitment of 12 sustained aircraft, there are other factors that ASTRA does not consider. Some concerns have been raised relating to the level of preparedness that would result given a 150-hour flying limit. It has been suggested that even with the use of ADCTS, the 150-hour limit is too low. These concerns are not addressed in this report, and have to be handled separately. There are also concerns as to the impact of a reduction in flying hours on the attrition of the CF-18 pilot community. This is a valid concern, particularly given the current stresses on the squadron due to manning issues. Once again, this is not considered in this report, but must be analyzed separately. Finally, some of the scenarios considered propose a reduction in the number of pilots. If this is pursued, the logical corollary is that the current force structure of four squadrons would have to be reassessed.

5 – Critical Mass Analysis

32. A request was received by DASOR to assist D Air SP, through the use of ASTRA, in determining the minimum possible size of each fleet, below which the fleet is no longer capable of providing a service, but is only capable of sustaining itself. Given the minimum service, ASTRA can determine the desired fleet and YFR requirements.

33. The service levels referred to herein are not based upon the currently agreed levels in the CAS Planning Guidance [5]. These levels are purely speculative, and are

meant to represent the lowest possible level of service that could be considered to be an effective contribution from the fleet.

34. Four fleets were considered in this critical mass analysis. These fleets are the CF-18 Hornet, CP-140 Aurora, CH-146 Griffon, and CH-124 Sea King fleets. Input was sought from subject matter experts for these fleets into the minimum level of commitment.

35. There was much trepidation among those polled for their opinions, with the understandable concern that their opinions would show up as official policy for the air force. They were being asked to give the minimum level of commitment, below which the existence of the fleet would not be of any operational utility. None of the experts wanted to see the fleets reduced to that size, and therefore were understandably hesitant to provide the required input.

36. The purpose of this study was not to determine the maximum magnitude of cuts possible to the various fleets. The purpose was to determine the bottom line for each fleet and to prevent cutbacks from totally destroying the utility of a fleet. If there is a greater appreciation of the minimum level of resources needed to maintain some capability in each fleet, it is easier to make decisions concerning the capability increments available above that level. As will be seen, some of the minimum commitment levels translated to resource levels that are very close to the current levels, indicating that any significant reductions to that fleet would call into question the reason for existence of the fleet.

CF-18 Hornet

37. Current plans call for a CF-18 fleet of 80 aircraft by the end of the decade. In 2004, the fleet YFR is to be reduced to 16,000 hours. For critical mass calculations, it is assumed that the NORAD ASA and the NORAD 3322 commitment, which together compromise the minimum Defence of Canada scenario, define the minimum capability. It is assumed that these commitments can be carried out simultaneously. The NORAD ASA commitment is for twelve aircraft to be deployed indefinitely within Canada, with eight of these aircraft actively participating at any time. The NORAD 3322 commitment is for six aircraft to be available for a short-term (less than six month) deployment. The fleet requirement for this level of commitment, as well as incremental commitments over and above this level, is given in Table 8. These calculations assume a YFR of 150 hours per pilot. This is lower than the current level, and is an estimate of flying levels once the Air Distributed Combat Training System (ADCTS) is operational in 2005.

	No Int'l Deploy **12 ASA** **6 NORAD 3322**	**6 Short Term Int'l** **12 ASA** **6 NORAD 3322**	**6 Sustained Int'l** **12 ASA** **6 NORAD 3322**
Pilots	29 CR pilots	45 CR pilots	51 CR pilots

	18 Instructors 6 BFPC Students	19 Instructors 10 BFPC Students	21 Instructors 12 BFPC Students
Aircraft	5 per TFS 10 OTU 4 AETE 3 Second Line 37 Total	7-8 per TFS 12 OTU 4 AETE 3 Second Line 48 Total	8-9 per TFS 14 OTU 4 AETE 4 Second Line 57 Total
YFR	1050-1200 per TFS 2187 OTU 580 Other 7117 Total	1650-1800 per TFS 2834 OTU 580 Other 10164 Total	1800-1950 per TFS 3332 OTU 580 Other 11562 Total

Table 8: CF-18 Fleet Critical Mass (150 Hours/Pilot)

38. The minimum size for the CF-18 fleet is 37 aircraft, with a YFR of 7117 hours and 29 combat-ready pilots. Although these calculations assumed the maintenance of four squadrons, this small fleet size would necessitate major changes in aircraft locations and squadron structure. Thus, at most two squadrons would be supported at this level. The calculated level of 37 aircraft would support solely the NORAD commitment and not permit any further deployment.

39. If an international deployment is included, the smallest package that is considered significant is six aircraft. Sending six aircraft on a single rotation, while still meeting NORAD and force generation commitments would require 48 aircraft and 45 pilots in the fleet. If the commitment is increased to six aircraft on an indefinite deployment, a minimum of 57 aircraft and 51 pilots are required.

40. Moving from a single rotation capability to an indefinite rotation requires an increment of nine aircraft and six pilots. In general, an indefinite deployment actually places a large strain on resources, so it may be somewhat surprising that the resource increment required is so low. In the previous instance, adding an unsustained capability is additive – the pilots and aircraft required for the unsustained deployment is added to the requirement for the NORAD commitment. The small size of this increment lies in the multiple rotations required for a sustained deployment. If there is a commitment with multiple rotations, some of the personnel destined for eventual deployment can be "double-hatted" and used to satisfy other commitments while awaiting their rotation to be deployed. For this reason, adding an additional, sustained commitment is not simply additive, but is interactive with already present deployments.

41. Another scenario involves the elimination of the CF-18 in an air-to-ground role. Although there have been no studies of the YFR savings that can be incurred if this role is discarded, removing the air-to-ground aspect of the current yearly readiness training leaves 125 hours per year per pilot. Using this value gives the results shown in Table 9.

	No Foreign Deploy **12 ASA** **6 NORAD 3322**	**6 Short Term** **12 ASA** **6 NORAD 3322**	**6 Sustained** **12 ASA** **6 NORAD 3322**
Pilots	29 CR pilots 18 Instructors 6 BFPC Students	45 CR pilots 19 Instructors 10 BFPC Students	51 CR pilots 21 Instructors 12 BFPC Students
Aircraft	4-5 per TFS 10 OTU 4 AETE 2 Second Line 34 Total	6-7 per TFS 12 OTU 4 AETE 3 Second Line 46 Total	7 per TFS 14 OTU 4 AETE 3 Second Line 52 Total
YFR	875-1000 per TFS 2187 OTU 580 Other 6392 Total	1375-1500 per TFS 2834 OTU 580 Other 9039 Total	1500-1625 per TFS 3332 OTU 580 Other 10287 Total

Table 9: CF-18 Fleet Critical Mass – No Air To Ground Role (125 Hours/Pilot)

42. The CAS Planning Guidance specifies an operational capability of eight aircraft for NORAD deployments within Canada. This is satisfied by the deployment of twelve aircraft in four locations within the country. Previously, this commitment was for an operational capability of four aircraft, to be satisfied by a deployment of six aircraft. If this level of commitment is used, and training for an air-to-ground role removed, the requirements are shown in Table 10.

	No Foreign Deploy **6 ASA** **6 NORAD 3322**	**6 Short Term** **6 ASA** **6 NORAD 3322**	**6 Sustained** **6 ASA** **6 NORAD 3322**
Pilots	25 CR pilots 17 Instructors 5 BFPC Students	41 CR pilots 19 Instructors 9 BFPC Students	471 CR pilots 20 Instructors 11 BFPC Students
Aircraft	4 per TFS 9 OTU 4 AETE 2 Second Line 31 Total	6 per TFS 12 OTU 4 AETE 3 Second Line 43 Total	6-7 per TFS 13 OTU 4 AETE 3 Second Line 47 Total
YFR	750-875 per TFS 2040 OTU 580 Other 5745 Total	1250-1375 per TFS 2743 OTU 580 Other 8448 Total	1375-1500 per TFS 3110 OTU 580 Other 9565 Total

Table 10: CF-18 Fleet Critical Mass – No Air To Ground, Reduced ASA (125 Hours/Pilot)

43. While the increment of aircraft, pilots, and YFR is relatively small when moving from a single-rotation deployment to an indefinite deployment, there are many other resources that are required. The part of the deployment imposing the largest burden on

the system during an indefinite deployment is the support requirements. Support trades, spare parts, and supply requirements are much more complex for an indefinite deployment than for a short-term deployment. While ASTRA does not yet look at these components, they will be a major part of any force structure decisions.

CP-140 Aurora

44. The second fleet that was considered for this analysis was the CP-140 Aurora fleet. These aircraft are the long-range maritime patrol aircraft, based on both the east and west coast. At present, there are 21 CP-140 aircraft (including three CP-140A Arcturus aircraft), but this will be reduced to 16 aircraft by the end of the decade. The fleet size is shown in Figure 1 [6]. The 2003/04 CP-140 YFR allocation is 11,000 hours.

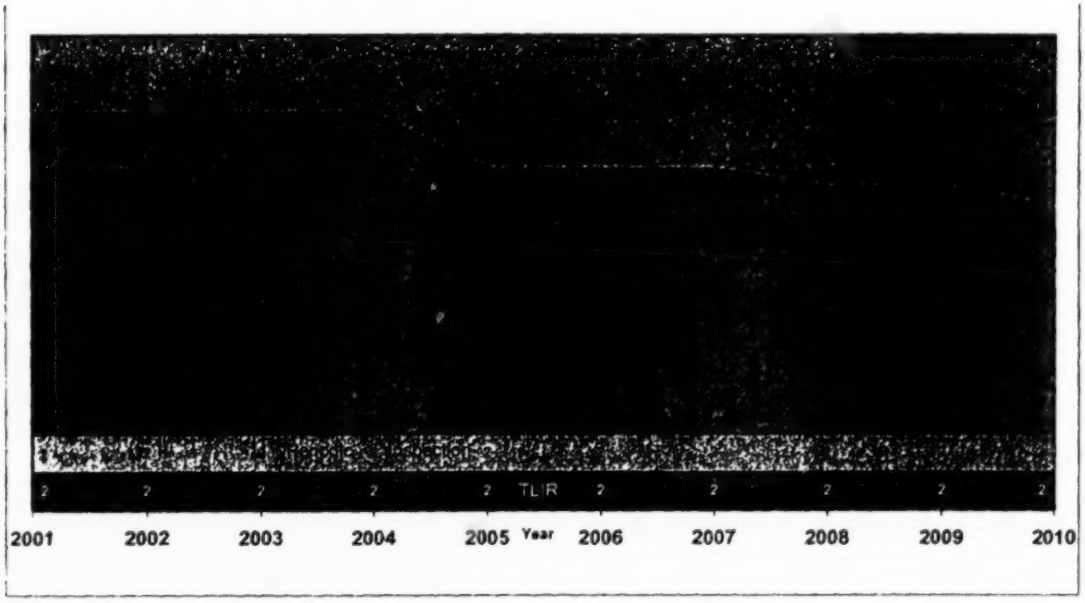

Figure 1: CP-140 Aurora Availability 2001 to 2010

45. The minimum identified requirement for the Aurora aircraft is a 24/7 surveillance operation for 14 days on one coast. This is interpreted as a series of flights, each of which has a two-hour transit time, five hours on station, followed by an additional two-hour transit time for return. As determined in [7] and incorporated into ASTRA, fulfilment of this commitment requires seven aircraft and six crews. The fleet

requirements required for a 24/7, 14-day operation on a single coast, as well as for a simultaneous operation on both coasts, is given in Table 11. This calculation uses YFR allocations for 03/04 for flying time dedicated to Chief Maritime Staff (CMS) (750 hrs/year), Department of Fisheries and Oceans (DFO) (430 hrs/year), Maritime Patrol Standardization and Evaluation Team (MPSET) (220 hrs/year), and Maritime Proving and Evaluation Unit (MPEU) (600 hrs/year). Note that the YFR given is the baseline requirement to prepare for 24/7 14 day operations, and does not include the additional YFR requirement to conduct the operation. The additional YFR required for this case is directly proportional to the number of such operations carried out each year, each of which requires 630 additional hours of flying.

	Single coast 24/7 14 day operation	**Two coast 24/7 14 day operation**
Pilots	6 Line crews 6 Exec crews 3 Student crews	12 Line crews 6 Exec crews 5 Student crews
Aircraft	7 Operational 2 OTU 1 T & E 4 Maintenance 14 Total	14 Operational 2 OTU 1 T & E 4 Maintenance 21 Total
YFR	3048 Readiness 1103 OTU 360 Admin Support 600 MP & EU 2262 Ops Support 7373 Total	5080 Readiness 1368 OTU 360 Admin Support 600 MP & EU 2262 Ops Support 9670 Total

Table 11: CP-140 Fleet Critical Mass

46. The current fleet size is sufficient to meet the single-coast commitment, however, a two-coast commitment will become impossible in the near future. Note that this level of resources does not permit any out-of-Canada deployments without compromising national surveillance capabilities.

47. These results are based on five crews and six aircraft providing continuous coverage. Over the length of a 14-day operation, this would totally exhaust pilot flying hour limits for the month. Thus, other operations and commitments would be jeopardized under this scenario. Any additional flexibility built into the system to accommodate this fact would require additional resources.

48. Also, the single coast scenario involves stationing aircraft on both coasts, but the resources on a single coast would be insufficient to conduct the operation. If activated,

aircraft and crews would have to be moved from one coast to the other. The impact of this on response time has not been considered.

CH-146 Griffon

49. The main role of the CH-146 helicopter is to provide aviation support to the army, with other roles relating to base SAR and JTF2 operations. In 2004, this fleet is being reduced to 85 aircraft with a YFR of 27,125 hours. It was considered that the JTF2, SAR, and CC2 (Capability Component 2 – army) support were the minimum commitments. This option includes the elimination of the reserve component of the fleet. The results are shown in Table 12.

	3 JTF2 9 SAR CC2 Support	**3 JTF2 9 SAR CC2 Support 3 Sustained**	**3 JTF2 9 SAR CC2 Support 16 Unsustained**
Pilots	20.5 Crews 10 BFO Students	49 Crews 20 BFO Students	57 Crews 22 BFO Students
Aircraft	12 Squadron 0 Operation 3 JTF2 3 OTU 9 SAR 2 T&E 5 Maintenance 34 Total	14 Squadron 3 Operation 3 JTF2 6 OTU 9 SAR 2 T&E 7 Maintenance 44 Total	11 Squadron 17 Operation 3 JTF2 7 OTU 9 SAR 2 T&E 10 Maintenance 59 Total
YFR	12487 Squadron 2800 CS & AETE 616 Other 15903 Total	15915 Squadron 2800 CS & AETE 616 Other 19331 Total	16000 Squadron 2800 CS & AETE 616 Other 19416 Total

Table 12: CH-146 Fleet Critical Mass

50. The number of required aircraft for this fleet is driven by the readiness requirements for all pilots. The assumption is made that available aircraft fly three times a day, 220 days a year. This figure has not been confirmed, but is based upon an estimate from 1 Wing. If aircraft cannot fly three times per day on average, but can only fly a lesser number of flights, the number of aircraft required will increase. The increase will be on the order of two to three extra aircraft if the average number of flights per day per aircraft drops to 2.5.

51. The smallest fleet size is 34 aircraft and a YFR of 15,903 hours, although this is for the somewhat counterintuitive scenario of training with the army, but being unable to deploy with them. If a small, indefinite deployment of three aircraft is added, 44 aircraft

and 19,331 YFR are required. A commitment of 16 aircraft for a single-rotation deployment requires 59 aircraft and a YFR of 19,416 hours.

52. If the SAR role of the CH146 is eliminated, and the size of the JTF2 contingent is doubled, the results are shown in Table 13.

	6 JTF2 CC2 Support	**6 JTF2 CC2 Support 3 Sustained**	**6 JTF2 CC2 Support 16 Unsustained**
Pilots	27.5 Crews 13 BFO Students	55.5 Crews 21 BFO Students	63.5 Crews 24 BFO Students
Aircraft	14 Squadron 0 Operation 6 JTF2 4 OTU 2 T&E 6 Maintenance 32 Total	15 Squadron 3 Operation 6 JTF2 6 OTU 2 T&E 8 Maintenance 40 Total	11 Squadron 17 Operation 6 JTF2 7 OTU 2 T&E 11 Maintenance 54 Total
YFR	13845 Squadron 2800 CS & AETE 616 Other 17261 Total	17087 Squadron 2800 CS & AETE 616 Other 20503 Total	17171 Squadron 2800 CS & AETE 616 Other 20587 Total

Table 13: CH-146 Fleet Critical Mass – No SAR / Increased JTF2

CH-124 Sea King

53. The CH-124 Sea King is the Canadian maritime helicopter that deploys onboard naval vessels. This fleet consists of 29 airframes and is allocated 9800 flying hours per year. Current commitments include one detachment[3] continuously deployed with the standing naval fleet Atlantic (SNFL), one indefinitely deployed detachment on each coast, four detachments for a short-term deployment with a naval task group, and two additional detachments for a second task group.

54. The critical mass for this fleet was calculated using a much-reduced commitment of one continuously deployed detachment. This would require a fleet size of 13 aircraft and 6487 YFR. Note that this result does not consider geographic issues. This capability would reside on one coast, and not on the other. If this minimum commitment is increased to one continuously deployed detachment and one short-term deployed detachment, the requirement is increased to 15 aircraft at 7424 YFR.

[3] For the CH-146, a detachment consists of one aircraft, two crews, and sufficient support staff to maintain the helicopter during a deployment.

	One Continuously Deployed Det	One Continuously One Short-Term Deployed Dets
Pilots	8 Crews 7 Students	21 Crews 8 BFO Students
Aircraft	6 Operational 3 OTU 1 OT&E 3 Maintenance 13 Total	7 Operational 4 OTU 1 OT&E 3 Maintenance 15 Total
YFR	2750 Readiness 2024 Operational 1113 OTU 400 OT&E 200 Other 6487 Total	3400 Readiness 2124 Operational 1300 OTU 400 OT&E 200 Other 7424 Total

Table 14: CH-124 Fleet Critical Mass

55. It should be noted that it is anticipated that major changes are forthcoming to the ASTRA model for CH-124 aircraft. At present, this is one of the least detailed models in ASTRA, and will shortly be expanded to account for other considerations.

5 – Conclusion

56. This report examined two questions; the first concerning proposed changes to the CF-18 operations, and the second considering critical mass of four fleets.

57. The results from ASTRA show that an increase of YFR to 210 hours per CF-18 pilot cannot be sustained with the current fleet structure. Even at the current YFR of 180 hours per pilot, there may be issues during the period of aircraft modernization if a large deployment is required.

58. For the critical mass of fleets, the results outlined in this report give the resource requirements for the smallest level of commitment for each of four fleets in the Canadian air force. The commitments as specified are at a very low level, and in most cases sacrifice the ability of the air force to respond to international crises.

59. As in the supply of most services, there are economies of scale to be found in the provision of air force capabilities. When small scales such as those examined in this report are considered, those economies are lost, and the result is a relatively expensive

force structure with limited capability. Although financial aspects have not been considered in this report, the cost of operating at the critical mass should be ascertained. An examination of the cost of incrementing capability can then be undertaken to identify optimal areas for further investment.

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DOCUMENT CONTROL DATA
(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1 ORIGINATOR (the name and address of the organization preparing the document Organizations for whom the document was prepared e g Establishment Sponsoring a contractor's report, or tasking agency, are entered in Section 8)

OPERATIONAL RESEARCH DIVISION
DEPARTMENT OF NATIONAL DEFENCE
OTTAWA, ONTARIO K1A 0K2

2 SECURITY CLASSIFICATION (overall security classification of the document, including special warning terms if applicable)

UNCLASSIFIED

3 TITLE (the complete document title as indicated on the title page Its classification should be indicated by the appropriate abbreviation (S, C or U) in parentheses after the title)

DETERMINING CF18 FLEET SIZE AND AIR FORCE CRITICAL MASS USING ASTRA

4 AUTHORS (last name, first name, middle initial)

ADAMSSON, JAY

5 DATE OF PUBLICATION (month Year of Publication of document)	6a NO OF PAGES (total containing information Include Annexes, Appendices, etc)	6b NO OF REFS (total cited in document)
APRIL 2003	22	7

7 DESCRIPTIVE NOTES (the category of document, e g technical report, technical note or memorandum If appropriate, enter the type of report e g interim, progress, summary, annual or final Give the inclusive dates when a specific reporting period is covered)

RESEARCH NOTE

8 SPONSORING ACTIVITY (the name of the department project office or laboratory sponsoring the research and development Include the address)

CHIEF OF THE AIR STAFF

9a PROJECT OR GRANT NO (if appropriate, the applicable research and development project or grant number under which the document was written Please specify whether project or grant)	9b CONTRACT NO (if appropriate, the applicable number under which the document was written)

10a ORIGINATOR's document number (the official document number by which the document is identified by the originating activity This number must be unique to this document)	10b OTHER DOCUMENT NOS (Any other numbers which may be assigned this document either by the originator or by the sponsor.)
DOR (MLA) RESEARCH NOTE 2003/02	

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This research note considers two questions that were directed towards DASOR. The first concerns proposed changes to the operations of the CF-18 fleet. The second concerned the critical mass of four fleets, defined as the fleet size below which a substantive contribution is no longer possible. These questions were analyzed using the Air Force Structure Analysis (ASTRA) tool.

14 KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document They should be selected so that no security classification is required Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included If possible keywords should be selected from a published thesaurus, e g Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title)

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